RESEARCH, DEVELOPMENT & TECHNOLOGY TRANSFER
QUARTERLY PROGRESS REPORT

Wisconsin Department of Transportation
DT1241 02/2011

INSTRUCTIONS:
Research project investigators and/or project managers should complete a quarterly progress report (QPR) for each calendar quarter during which the projects are active.

WisDOT research program category: ☐ Policy research ☒ Wisconsin Highway Research Program ☐ Other ☐ Pooled fund TPF#		Report period year: 2012 ☐ Quarter 1 (Jan 1 – Mar 31) ☐ Quarter 2 (Apr 1 – Jun 30) ☒ Quarter 3 (Jul 1 – Sep 30) ☐ Quarter 4 (Oct 1 – Dec 31)
Project title: Laboratory Study of Optimized Concrete Pavement Mixtures		
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WisDOT project ID: 0092-13-04	Other project ID: PRJ63JN	Project start date: 8/1/2012
Original end date: 1/31/2015	Current end date: 1/31/2015	Number of extensions: 0

Project schedule status:
☒On schedule ☐On revised schedule ☐Ahead of schedule ☐Behind schedule

Project budget status:

Total Project Budget	Expenditures Current Quarter	Total Expenditures	% Funds Expended	% Work Completed
$199,185.00	$25,823.55	$25,823.55	13%	10%

Project description:

The Wisconsin Department of Transportation (WisDOT) continues to investigate the feasibility of optimization of paving mixtures as a means to improve the engineering properties, lower the required cementitious materials content, reduce cost, and minimize the environmental impacts. Previous research conducted by WisDOT concluded that concrete produced with reduced cementitious materials content had an adequate durability; however, these mixes frequently demonstrated poor workability. As a result, a multi-faceted approach to optimizing mixture proportioning for low-slump mixtures used in concrete pavements is needed for WisDOT to realize the benefits related to the use of lower cementitious materials contents. This approach includes the use of supplementary cementitious materials (SCMs), optimized aggregate gradations, and the use of superplasticizers (high-range water reducing, HRWR admixtures). Current WisDOT practice minimizes the use of portland cement through replacement with SCMs, but does not address the use optimized gradation or superplasticizers. Therefore, additional research is needed to support the development of specifications inclusive of the aforementioned factors to improve the performance and sustainability of concrete paving mixtures used in Wisconsin. This research project evaluates the feasibility of expanding current specifications to incorporate optimized superplasticized concrete in sustainable concrete paving applications.

The goal of this study is to produce guidelines for optimized concrete mix design by evaluating the performance of a range of concrete mixtures. The proposed performance evaluation of optimized concrete will include workability (slump and VB-test), air content, unit weight, compressive and flexural strength, freeze-thaw resistance, and rapid chloride permeability in accordance with relevant AASHTO/ASTM standards. The results of the research will be used to recommend the aggregate gradations and dosage of superplasticizers/HRWR admixtures that will accommodate the use of reduced cementitious materials for the low-slump concrete paving mixtures.

To provide the comprehensive optimization of superplasticized concrete, the proposed project will focus on the following objectives:

1. Develop a detailed, final testing matrix for comprehensive testing of aggregate gradations, SCMs and HRWR admixtures in concrete.
2. Evaluate and compare the composition, microstructural features, and physical properties of different types of cementitious materials essential for their compatibility with HRWR admixtures affecting their performance in concrete.
3. Evaluate the effect of HRWR admixtures on the fresh properties and mechanical performance of concrete.
4. Evaluate the effect of aggregate gradations on the fresh properties and mechanical performance of concrete.
5. Evaluate the effect of SCMs and HRWR admixtures on the stability of air void system, fresh properties, mechanical performance, and durability of concrete.
6. Develop and recommend for practical application an express-method capable of evaluating the performance of SCMs and HRWR admixtures in concrete.
7. Provide Life Cycle Analysis of sustainable optimized concrete paving applications based on the experimental results; submit a final report and recommendations for future work and revision of current specifications.

Progress this quarter

The research team collected relevant publication and started a review of the most recent literature concerning the principal parameters affecting the performance of superplasticized low-slump concrete, including mixture/aggregate proportioning, the effect of the HRWR admixture type, the effect of SCMs on mechanical properties, and durability.

The preliminary experimental matrix design was developed based on the vast database gathered by the University of Wisconsin collaborative team (as per as Task 2). The proposed experimental matrix was reported to TOC by the PIs.

Under Task 3, the research team evaluated materials to be used in the Phase 1 of research as approved by the WisDOT experimental matrix; fabricated test specimens, and measured/documented properties of mortars. The materials listed in the RFP (Phase 1) such as South aggregates combinations, cement and SCMs (from single source), all chemical admixtures were collected and characterized prior to the preparation of the mortar/concrete mixes. All materials, including fly ash, slag and cement, are characterized according to relevant AASHTO/ASTM standards.

The PIs started to evaluate the compatibility of supplementary cementitious materials (SCMs) and superplasticizers using express method based on mortar (ASTM C109) and mini-slump tests. The isothermal calorimeter (TAM Air from TA Instruments) was used to detect the rate of heat release from a hydration mixture due to hydration and so correlate setting characteristics, compatibility of different materials, early-strength development, the effect of chemical admixtures.

Different binary aggregate combinations were characterized by compacted packing density using VB apparatus.

Anticipated work next quarter:

The second step of Task 1 will explore the different empirical relationships between the concrete properties to be measured and the principal parameters affecting the performance. This survey and literature update will be used for the refinement of the research plan. Possible modifications of the research plan will be discussed with the TOC in a meeting prior to the testing phase of the research.

The effect of different types of HRWR/plasticizers and AE additives in various cementitious systems (portland/with SCMs) will be further quantified by evaluating the isothermal hydration kinetics during the early period of hydration and using mini-slump, air content/density, mortar flow and mortar strength.

Different ternary aggregate combinations will be characterized by compacted packing density using the VB apparatus. Based on different packing models, the combined particle size distribution of aggregates will be specified. The follow-up research will adjust the proportion of sand and coarse aggregates to meet the target curves with a minimal deviation. The preliminary investigation of concretes in respect to optimization of aggregates, HRWR, and air entraining admixture will be performed. Concrete mixtures will be proportioned, mixed, cured and tested according to the WisDOT specifications.

The research team will provide the statistical analysis of experimental data; develop the relationships between the experimental factors and compare these with AASHTO/WisDOT/ACI requirements; develop models between the mortar express-tests and concrete performance.

Circumstances affecting project or budget: None

Attach / insert Gantt chart and other project documentation Enclosed

FOR WISDOT USE ONLY

Staff receiving QPR:	Date received:
Staff approving QPR:	Date approved:

Gantt Chart / Work Time Schedule

ID	Task Name	Duration	Start
1	**Entire Project**	**653 days?**	**Wed 8/1/12**
2	**Task 1 - Literature Review**	**420 days**	**Wed 8/1/12**
3	Review literature and gather information	70 days	Wed 8/1/12
4	Update literature review as needed	350 days	Wed 11/7/12
5	Task 2 - Finalize the Research Matrix	26 days	Wed 8/1/12
6	**Task 3 - Evaluate Concrete Specimens**	**548 days?**	**Wed 8/1/12**
7	**Collect & Characterize Materials**	**65 days?**	**Wed 8/1/12**
8	Collect Cementitous Materials	50 days	Wed 8/1/12
9	**Characterize Cementitious Materials**	44 days	Wed 8/29/12
10	Identify and collect aggregates	45 days?	Wed 8/1/12
11	Characterize aggregates	30 days	Wed 9/19/12
12	**Optimization of Aggregates & HRWR**	**180 days**	**Wed 11/21/12**
13	Prepare optimized aggregates	180 days	Wed 11/21/12
14	HRWR - cement compatibility & dosages	180 days	Wed 11/21/12
15	**Optimized Mixtures**	**308 days**	**Wed 7/3/13**
16	Plastic properties	180 days	Wed 7/3/13
17	Compressive Strength	220 days	Fri 7/12/13
18	Flexure Strength	220 days	Fri 7/12/13
19	Freeze-thaw Resistance	280 days	Mon 8/12/13
20	Rapid Chloride Permeability	250 days	Mon 8/12/13
21	**Task 4 - Data Analysis**	**80 days**	**Wed 5/21/14**
22	Comprehensive data analysis	80 days	Wed 5/21/14
23	**Task 5 - Reporting**	**651 days**	**Fri 8/3/12**
24	Draft final report	50 days	Wed 8/13/14
25	Report presentation to RPTOC	10 days	Wed 10/22/14
26	Review, Revise and Submit Final Report	50 days	Wed 11/5/14
27	**Quarterly Progress Reports**	651 days	Fri 8/3/12